

AXAF Science Center

Harvard-Smithsonian
Center for Astrophysics

MEMORANDUM

February 28, 1996

File: /home/garcia/axaf/asc/mp/guide.stars/gssa/test.v2.1/mpwgtel2.tex
To: MPSWG Members
From: Michael Garcia
Subject: Fraction of Sky Accessible in Single 180° Slew

This memo is in response to an action item taken at the MPSWG Telecon Feb 14, 1996. Reference material includes:

SAO Memo From Robert Cameron, Feb 14, 1995, "Constraints on selection of acquisition stars"

TRW Memo AXAF.95.333.011, S. Parker, 24 Feb 1995, "Preliminary Requirements for Worst-Case Acquisition Star Algorithm"

ASC Memo From Michael Garcia, May 3, 1995, "Tests of Acquisition Star Algorithm, V2.1"

The action item was to assess the fraction of AXAF targets which could be slewed to directly and lock onto acquisition stars in a worst-case 180° slew. The concern is that the acquisition stars may have "spoofers" in the search region, therefore causing the ACA to lock up on the wrong star.

The problem was addressed by running the ASC prototype acquisition star selection algorithm (SSA V2.1) with a range of "search_box_sizes", representing a range in gyro pointing errors after a 180° slew. The potential target list was taken from the the first ~ 1000 Einstein pointings in a RA sorted list, which covers a range in galactic latitude and may be representative of AXAF pointing lists. Potential acquisition stars were selected from the AGASC (V1.0). Stars within 1.62 magnitudes, and within the "clear_circle" were taken as spoofer stars. As there is no color information in AGASC V1.0, magnitudes were computed based on an average correction from the HST magnitudes to the ACA bandpass. FID lights

search_box_size (sbs), SSA parameter	clear_circle $= 2 \times \sqrt{(2)} \times sbs$	fraction accessible	RAC Fig 1 clear search region $= 2 \times 4\sigma$ equiv 4σ error	RAC page 3 SSA Acq QC clear region $= 4 \times \sqrt{(2)} \times 4\sigma$ equiv 4σ error
133"	372"	99%	186"	66"
200"	560"	90%	280"	100"
267"	747"	65%	373"	133"
600"	1680" (28')	0.2%	840"	300"

Table 1: Results of Trial Acquisition Star Selection, SSA V2.1, AGASC V1.0

were also considered as “spoofers”, if they were within the “clear_circle” of the candidate acquisition star.

Column one lists the SSA parameter “search_box_size”. Figure 1 below describes how this parameter is used in the algorithm. Column two lists the radius of the circle which is searched for potential spoofers (stars within 1.62 magnitudes of the potential acquisition star).

Column three lists the “fraction accessible”, this is the fraction of targets from a potential AXAF list for which two or more Acquisition stars could be found in the AGASC, given the clear_circle requirement in column 2. Note that this is NOT the *probability* of a successful acquisition of the stars, that is either 100% or 0% for any given target/slew combination. This number is the fraction of the set of trial target/slew combinations for which the probability of success is 100%. One can determine if any given target/slew is possible BEFORE attempting the maneuver, and break the maneuver into pieces if need be.

Column four lists the equivalent 4σ gyro error from Figure 1 of Rob Cameron’s memo on Feb 14, 1995 “Constraints on selection of acquisition stars”. This is the appropriate error to use if the ACA searches for potential acquisition stars in a circle (rather than in a square). It also is appropriate if the SSA filters potential acquisition stars with quality codes built into the AGASC.

Column five lists the equivalent 4σ gyro error if the ACA searches in a square, and the SSA uses built in quality codes for star selection, after page 3 of Rob Cameron’s memo of Feb 14, 1995.

If the ACA searches in a box, and the filtering (selection) of acquisition stars is done in a square (which would require it to be done in OFLS and for a pre-determined roll), then

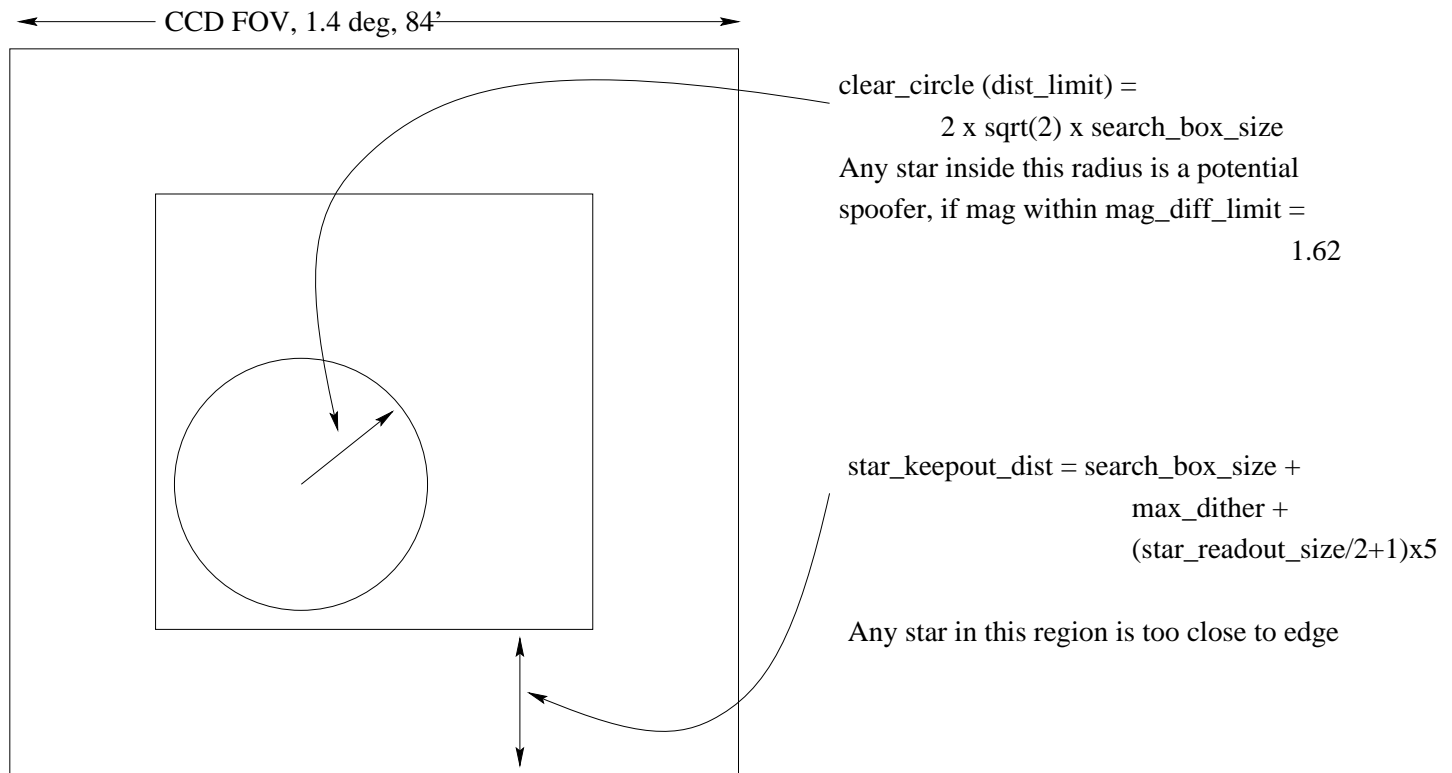


Figure 1: Usage of SSA Parameter "search_box_size"

the appropriate 4σ error is somewhere in between columns four and five.

ERROR MODEL



ERROR TERMS HAVING AN IMPACT ON SLEW ACCURACY ARE AS SHOWN IN THE TABLE BELOW

Error Term	Method of Compensation	Symbol for RMS Residual Uncertainty or Instability	Residual 3-sigma Uncertainty or Instability
Scale Factor Asymmetry and Nonlinearity	Two-Sided Scale Factor and Cubic Fit	σ_{sin}	50 ppm
Scale Factor Uncertainty	Deterministic Exponential Aging Correction, Calibration of Remainder	σ_{sf}	15 ppm / $\sqrt{3}$ days
Misalignment Uncertainty	Calibrated	σ_c	1.5 arcsec / $\sqrt{3}$ days
Gyro Bias	Calibrated	σ_b	5 arcsec / hour
Gyro Angle Random Walk	Data Weighting in Calibration Filter	σ_v	0.06 arcsec / $\sqrt{\text{sec}}$
Gyro Rate Random Walk	Data Weighting in Calibration Filter	σ_u	3×10^{-5} arcsec / $\sqrt{\text{sec}^3}$
Star Tracker Temporal	Centroiding Algorithms	σ_{stt}	1 arcsec
Star Tracker Spatial	Calibrated on Ground	σ_{sts}	0.6 arcsec
Star Catalog Errors	Use Best Available	σ_{cat}	0.6 arcsec

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input cal accuracy

ASC

4.3.5.3 Slew Error Using Baseline Estimator

The plot below demonstrates the performance of the baseline estimator described in [2]. The solid line is the performance of the estimator assuming misalignment instability as presented in table 4.3.5.1-1. The dashed line is the performance of the baseline estimator assuming no instability in the gyro misalignments.

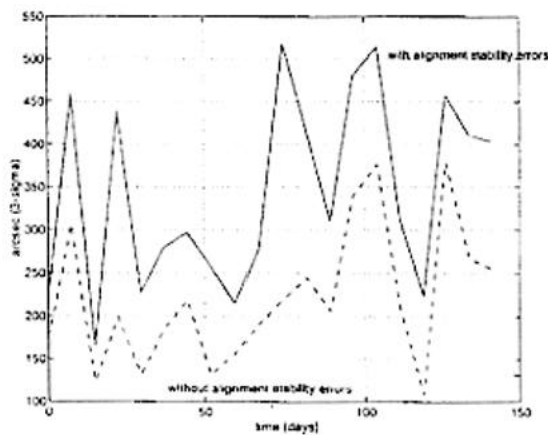


Figure 4.3.5.3-1: Worst Case Pointing Error For Baseline Calibration

This discrepancy in performance versus the Kalman Filter approach is due to the fact that the baseline estimator does not weight data based upon the instabilities in gyro bias (angle and rate random walk), nor upon instabilities in scale factors and misalignments [2].

Gyro / ACA Alignment Stability

Two Terms : $Gyro / ACA = Gyro / IRU + IRU / ACA$

Random Walk Model - $Gyro / ACA$: $15 \text{ sec} / \sqrt{3 \text{ days}} = 8.6 \text{ sec} / \sqrt{\text{day}}$
from:

$$Gyro / IRU : 35 \text{ sec} / \sqrt{45 \text{ days}} = 5.2 \text{ sec} / \sqrt{\text{day}}$$

(from IRU spec - 35 sec alignment shift over 45 days of protoflight testing)

$IRU / ACA : ?$

Gyro / IRU

Gyro / IRU alignment stability is likely to be good to

~ 35 sec over IRU 9 year life

~ 20 sec over AXAF 5 years on orbit

(for reference : $\left. \begin{array}{l} 20 \text{ sec alignment error} \\ 180^\circ \text{ maneuver} \end{array} \right\} \rightarrow 40 \text{ sec attitude error}$

PRELIMINARY
IRU/IACA Stability

DECLERK

Components	1 Second (arcsec)	For 1 °F (arcsec)	ΔT	40 hr (arcsec)	EOL (arcsec)
AC Mount (1)				0.082	
AC Mount Align Plate (1)				0.101	
AC Mount Align Shim (1)				0.083	
AC Mount Bracket (1)				7.83	
AC Mount to HRMA IF Plane (2)				0.41	0.8
Total AC IF to HRMA IF				8.488	
IRU #1					
Radiator Plate/Mt (3)	0.00036	0.919	780		
F-Box Fittings (3)	0.00062	0.114	780		
Forward Bulkhead (4)		0.773	5	3.865	
Strut Fittings (4)		0.586	5	2.93	
HRMA Strut to HRMA IF (4)		0.264	5	1.32	
Total IRU#1				780	
IRU #2					
F Box Fittings (3)	0.000665	0.122	780		
IRU Bracket & Radiator (3)	0.000344	1.578	780		
Forward Bulkhead (4)		0.009	5	4.545	
Strut Fittings (4)		0.383	5	1.815	
HRMA Strut to HRMA IF (4)		0.264	5	1.32	
Total IRU#2				780	
Total IRU IF to HRMA IF					
RSS OBA & HRMA					
References:					
1) AXAF-94-0231 Bedzyk					
2) AXAF-94-0178 Thraasher					
3) AXAF-95-0323 Gossard					
4) AXAF-96-0002 Brown					

See Page 1
AXAF-94-0231
AXAF-95-0323
Gossard

RSS THE
LARGER OF
THESE WITH
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Block Out
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How
much

↑
expected up
gradient over
16 hours.

Kat
Thermal
work
group still need to
cut with TPU

Lee Harper
AWP
Gary Compagno
Model 4-1-1

IRU/ACA

$$\text{IRU/ACA} = \text{IRU/HRMA} + \text{HRMA/ACA}$$

$$\text{IRU}_1/\text{HRMA} = 8.1 \text{ sec} + .919 \text{ TBD}_1 + .114 \text{ TBD}_2$$

$$\text{IRU}_2/\text{HRMA} = 7.7 \text{ sec} + 1.578 \text{ TBD}_2 + .122 \text{ TBD}_4$$

$$\text{for TBD}_1 = 5^\circ\text{F}, \text{ IRU/HRMA} \leq 16.2 \text{ sec}$$

$$\text{" " } 20^\circ\text{F}, \text{ " } \frac{42.6 \text{ sec}}{41.7}$$

~~IRU/ACA $\leq 18.3 \text{ sec}$~~
~~42.6 sec~~

$$\text{HRMA/ACA} = 8.5 \text{ sec}, \text{ so}$$

$$\text{for TBD}_1 = 5^\circ\text{F}, \text{ IRU/ACA} \leq 18.3 \text{ sec}$$

$$\text{" " } 20^\circ\text{F} \text{ " } = 42.6 \text{ sec}$$